

# Strangeness $s = -3$ dibaryons in a chiral quark model

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## Abstract

The structures of  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  with strangeness  $s = -3$  are dynamically studied in both the chiral SU(3) quark model and the extended chiral SU(3) quark model by solving a resonating group method (RGM) equation. The first model parameters are taken from our previous work, which gave a satisfactory description of the energies of the baryon ground states, the binding energy of the deuteron, the nucleon-nucleon(NN) scattering phase shifts, and the hyperon-nucleon (YN) cross sections. The effect from the vector meson fields is very similar to that from the one-gluon exchange interaction, both in the chiral SU(3) quark model and the extended chiral SU(3) quark model, the  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems are weakly bound states. The second model parameters are also taken from our previous work by fitting the KN scattering process. When the mixing of scalar mesons are considered, the  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems change into unbound state.

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## I. INTRODUCTION

Searching dibaryon both theoretically and experimentally has attracted worldwide attention since Jaffe predicted the H particle in 1977[1]. No doubt, studying dibaryon can enrich our knowledge of the strong interaction in the short-range and can further understand the basic theory of the strong interaction, Quantum chromodynamics (QCD), especially its non-perturbative QCD (NPQCD) effect. Because of complexity in NPQCD effect at the lower energy region, one has to develop QCD-inspired models, e.g., the MIT bag model [2], cloudy bag model [3], Friedberg-Lee nontopological soliton model[4], Skyrme topological soliton model [5], the constituent quark model [6, 7], etc. Recently, there has been a hot debate regarding the proper effective degrees of freedom of the constituent quark model [8].

Among those models, the chiral  $SU(3)$  quark model is one of the most successful ones [9]. With such model, not only the single baryon properties can be explained[10], but also the nucleon-nucleon (NN) scattering phase shifts and the hyperon-nucleon (YN) cross sections can be better reproduced [9]. Based on this chiral  $SU(3)$  quark model, the prediction of possible dibaryons can be found in Refs.[11]. In Ref.[12], we further extended our chiral  $SU(3)$  quark model to include the coupling between the quark and vector chiral fields, named as the extended  $SU(3)$  quark model. Such extension was made mainly based on the following facts. Firstly, in the study of NN interactions on quark level, the short-range feature can be explained by one gluon exchange (OGE) interaction and the quark exchange effect, while in the traditional one boson exchange (OBE) model on baryon level it comes from vector meson ( $\rho, \omega, K^*$  and  $\phi$ ) exchanges. Secondly, Glozman and Riska proposed the boson exchange model [13], and found that the OGE can be replaced by vector-meson coupling in order to elucidate baryon structure. Therefore, in Ref. [12], the vector meson exchange was dynamically studied on quark level. From our study on deuteron structure and the  $NN$  scattering phase shifts in the extended chiral  $SU(3)$  quark model, we find that quark-vector chiral field coupling interactions can substitute the OGE mechanism on quark level. In the extended chiral  $SU(3)$  quark model, instead of the OGE interaction, the vector meson exchanges play a dominate role in the short range part of the quark-quark interactions. Since geometric size of a dibaryon is small, the short range feature of the interactions should be important in describing its structure. Hence, a further investigation on structure of dibaryon in the extended chiral  $SU(3)$  quark model should be helpful in resolving this issue.

As far as the quark-quark interaction is concerned,  $N\Omega$  and  $\Delta\Omega$ , just like  $N\phi$  state, are special systems which are composed of two color singlet hadrons with no common flavor quarks. In  $N\Omega$

or  $\Delta\Omega$  one-channel study, there is no quark exchange between  $N(\Delta)$  and  $\Omega$  cluster, and no OGE interaction. Whether  $N\Omega$  or  $\Delta\Omega$  can form a bound state like  $N\phi$  [14, 15] is an interesting issue. Moreover, in Ref. [16], Li and Shen gave the prediction of binding energies of  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems in the chiral  $SU(3)$  quark model, and their results showed that  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems are the weakly bound states. Because of the available nucleon beam and the only weak decay modes of  $\Omega$ , they think the  $N\Omega$  state would be easier to search experimentally. In this work, we will further study the two special  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems in the extended chiral  $SU(3)$  quark model, in which vector meson exchange dominates the short range interaction. This study will make us deeply understanding the short range quark-quark interaction and get more knowledge of the coupling between quark and  $\sigma$  chiral field.

The paper is arranged as follows. A brief introduction of the model is outlined in section II. The results and discussions are provided in section III. A summary is given in section IV.

## II. FORMULATION

The chiral  $SU(3)$  quark model [9] and the extended chiral  $SU(3)$  quark model[12] has been widely described in the literature [9, 12] and we refer the reader to those works for details. Here we just give the salient feature of these two models.

In these two models, the total Hamiltonian of baryon-baryon systems can be written as

$$H = \sum_i T_i - T_G + \sum_{i<j} V_{ij}, \quad (1)$$

where  $\sum_i T_i - T_G$  is the kinetic energy of the system, and  $V_{ij}$  represent the quark-quark interactions,

$$V_{ij} = V_{ij}^{\text{OGE}} + V_{ij}^{\text{conf}} + V_{ij}^{\text{ch}}, \quad (2)$$

where  $V_{ij}^{\text{OGE}}$  is the OGE interaction, and  $V_{ij}^{\text{conf}}$  is the confinement potential.  $V_{ij}^{\text{ch}}$  represents the chiral fields induced effective quark-quark potential. In the chiral  $SU(3)$  quark model,  $V_{ij}^{\text{ch}}$  includes the scalar boson exchanges and the pseudoscalar boson exchanges,

$$V_{ij}^{\text{ch}} = \sum_{a=0}^8 V_{\sigma_a}(\mathbf{r}_{ij}) + \sum_{a=0}^8 V_{\pi_a}(\mathbf{r}_{ij}) \quad (3)$$

and in the extended chiral  $SU(3)$  quark model, the vector boson exchange are also included,

$$V_{ij}^{\text{ch}} = \sum_{a=0}^8 V_{\sigma_a}(\mathbf{r}_{ij}) + \sum_{a=0}^8 V_{\pi_a}(\mathbf{r}_{ij}) + \sum_{a=0}^8 V_{\rho_a}(\mathbf{r}_{ij}) \quad (4)$$

Here  $\sigma_0, \dots, \sigma_8$  are the scalar nonet fields,  $\pi_0, \dots, \pi_8$  are the pseudoscalar nonet fields and  $\rho_0, \dots, \rho_8$  are the vector nonet fields. The expressions of these potentials can be found in the literature [12].

All the model parameters are taken from our previous work, which gave a satisfactory description of the energies of the baryon ground states, the binding energy of the deuteron, the NN scattering phase shifts. Here we briefly give the procedure for the parameter determination. The three initial input parameters, i.e., the harmonic-oscillator width parameter  $b_u$ , the up(down) quark mass  $m_{u(d)}$  and the strange quark mass  $m_s$ , are taken to be the usual values:  $b_u = 0.5$  fm for the chiral SU(3) quark model and 0.45 fm for the extended chiral SU(3) quark model  $m_{u(d)} = 313$  MeV, and  $m_s = 470$  MeV. The coupling constant for scalar and pseudoscalar chiral field coupling,  $g_{ch}$ , is fixed by the relation:

$$\frac{g_{NN\pi}^2}{4\pi} = \frac{9}{25} \frac{m_u^2}{M_N^2} \frac{g_{ch}^2}{4\pi}, \quad (5)$$

with the experimental value  $g_{NN\pi}^2/4\pi = 13.67$ . The coupling constants for vector coupling of the vector-meson field is taken to be  $g_{chv} = 2.351$  (set I) and  $g_{chv} = 1.973$  (set II), respectively, the same as used in the NN case[12]. The masses of the mesons are taken to be the experimental values, except for the  $\sigma$  meson. The  $m_\sigma$  is adjusted to fit the binding energy of the deuteron. The OGE coupling constants and the strengths of the confinement potential are fitted by baryon masses and their stability conditions. All the parameters are tabulated in Table I, where the first set is for the original chiral SU(3) quark model, the second and third sets for the extended chiral SU(3) quark model by taking  $f_{chv}/g_{chv}$  as 0 and 2/3, respectively. Here  $f_{chv}$  is the coupling constant for tensor coupling of the vector meson fields.

From Table I one can see that for both set II and set III,  $g_u^2$  and  $g_s^2$  are much smaller than the values of set I. This means that in the extended chiral SU(3) quark model, the coupling constants of OGE are greatly reduced when the coupling of quarks and vector-meson field is considered. Thus the OGE that plays an important role of the quark-quark short-range interaction in the original chiral SU(3) quark model is now nearly replaced by the vector-meson exchange. In other words, the mechanisms of the quark-quark short-range interactions in these two models are quite different.

In order to obtain more information of the structure of  $N\Omega$  and  $\Delta\Omega$  systems, parameters fitting kaon-nucleon ( $KN$ ) scattering process [17] are also adopted, where the scalar meson mixing between the flavor singlet and octet mesons must be considered.

With all parameters determined, the two baryon systems on quark level can be dynamically

TABLE I: Model parameters. Meson masses and cutoff masses:  $m_\pi=138\text{MeV}$ ,  $m_K=495\text{ MeV}$ ,  $m_\eta=549\text{ MeV}$ ,  $m_{\eta'}=957\text{ MeV}$ ,  $m_{\sigma'} = m_\epsilon = m_\kappa=980\text{ MeV}$ ,  $m_\rho=770\text{ MeV}$ ,  $m_{K^*}=892\text{ MeV}$ ,  $m_\omega=782\text{ MeV}$ ,  $m_\phi=1020\text{ MeV}$ ,  $\Lambda=1100\text{ MeV}$  for all mesons.

	Chiral $SU(3)$ quark model	Extended Chiral $SU(3)$ quark model	
		set I	set II
$b_u(\text{fm})$	0.5	0.45	0.45
$g_{NN\pi}$	13.67	13.67	13.67
$g_{\text{ch}}$	2.621	2.621	2.621
$g_{\text{chv}}$	0	2.351	1.973
$f_{\text{chv}}/g_{\text{chv}}$	0	0	2/3
$m_\sigma(\text{MeV})$	595	535	547
$g_u^2$	0.766	0.056	0.132
$g_s^2$	0.846	0.203	0.250
$a_{uu}(\text{MeV}/\text{fm}^2)$	46.6	44.5	39.1
$a_{us}(\text{MeV}/\text{fm}^2)$	58.7	79.6	69.2
$a_{us}(\text{MeV}/\text{fm}^2)$	99.2	163.7	142.5
$a_{uu}^0(\text{MeV}/\text{fm}^2)$	-42.4	-72.3	-62.9
$a_{us}^0(\text{MeV}/\text{fm}^2)$	-36.2	-87.6	-74.6
$a_{ss}^0(\text{MeV}/\text{fm}^2)$	-33.8	-108.0	-91.0
$B_{\text{deu}}(\text{MeV})$	2.13	2.19	2.14

studied in the framework of the RGM, a well established method for studying the interaction between two clusters. The wave function of the two baryon systems is of the form

$$\Psi_{ST} = \mathcal{A}[\phi_A(\xi_1, \xi_2)\phi_B(\xi_4, \xi_5)\chi(\mathbf{R}_{\mathbf{AB}})], \quad (6)$$

where  $\xi_1$  and  $\xi_2$  are the internal coordinates for the cluster A, and  $\xi_4$  and  $\xi_5$  are the internal coordinates for the cluster B.  $\mathbf{R}_{\mathbf{AB}} = \mathbf{R}_{\mathbf{A}} - \mathbf{R}_{\mathbf{B}}$  is the relative coordinate between the two clusters A and B. The  $\phi_A$  and  $\phi_B$  are the antisymmetrized internal cluster wave function of A and B, and  $\chi(\mathbf{R}_{\mathbf{AB}})$  the relative wave function of the two clusters. The symbol  $\mathcal{A}$  is the antisymmetrizing

TABLE II: Binding energy  $B$  and rms  $\bar{R}$  of the  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  dibaryons.  $B = -(E_{AB} - M_A - M_B)$ ,  $\bar{R} = \sqrt{\langle r^2 \rangle}$ .

		$N\Omega_{(2,1/2)}$		$\Delta\Omega_{(3,3/2)}$
Chiral SU(3)		$B(\text{MeV})$	3.0	0.6
quark model		$\bar{R}(\text{fm})$	1.2	1.3
Extended	set I	$B(\text{MeV})$	20.4	25.6
chiral SU(3)		$\bar{R}(\text{fm})$	0.9	0.9
quark model	set II	$B(\text{MeV})$	12.1	14.4
		$\bar{R}(\text{fm})$	1.0	0.9

operator defined as

$$\mathcal{A} = 1 - \sum_{i \in A, j \in B} P_{ij}, \quad (7)$$

where  $P_{ij}$  is the permutation operator of  $i$ -th and  $j$ -th quarks. Expanding unknown  $\chi(\mathbf{R}_{AB})$  by employing well-defined basis wave functions, such as Gaussian functions, one can solve the RGM equation for a bound-state problem or a scattering one to obtain the binding energy or scattering phase shifts for the two-cluster system. The details of solving the RGM equation can be found in Refs.[18, 19, 20].

### III. RESULTS AND DISCUSSION

As mentioned above, the  $N\Omega$  and  $\Delta\Omega$  systems are very special two-baryon states, since there is no OGE interaction between these two clusters. In these two systems, the expectation values of the antisymmetrizer in the spin-flavor-color space is equal to 1. It means that there is no quark effect, and whether the system is bound merely depends on the characteristics of the interaction induced by the chiral-quark fields coupling. In this work, we will give the results by fitting NN and KN scattering process both in the chiral SU(3) quark model and in the extended chiral SU(3) quark model, respectively.

#### 1. Fit the NN scattering process

Firstly, the same as  $N\phi$  state [15], the model parameters, listed in Table I, are taken from our previous work, which gave a satisfactory description of the energies of the baryon ground states, the binding energy of the deuteron, the NN scattering phase shifts. The parameters in the extended

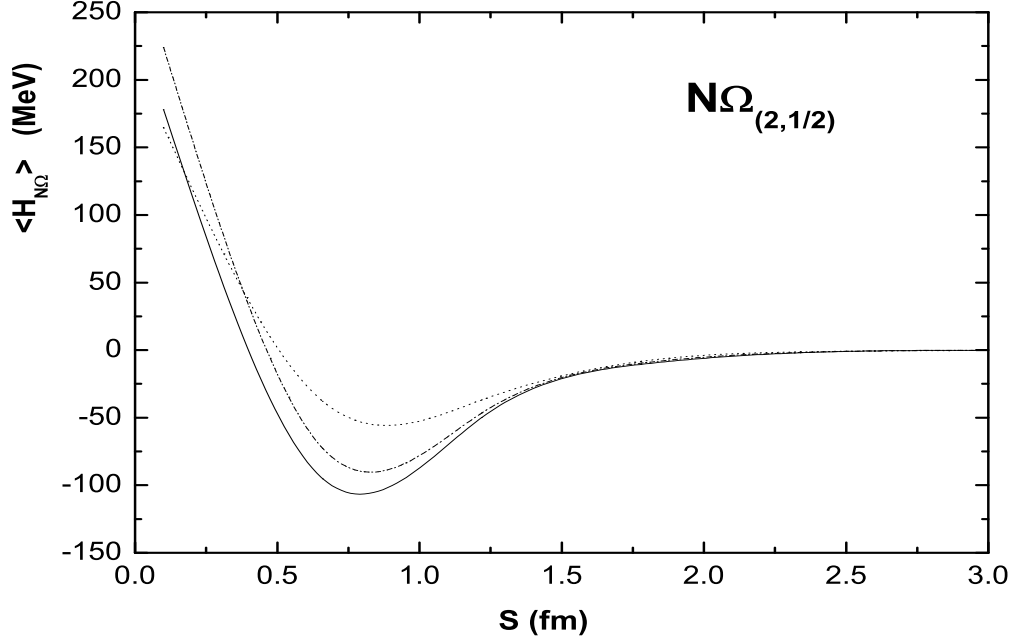


FIG. 1: The GCM matrix elements of the Hamiltonian for  $N\Omega_{(2,1/2)}$  system. The dotted line represents the results obtained in original chiral  $SU(3)$  quark model, and the solid and dash-dotted lines represent the results in extended chiral  $SU(3)$  quark model with set I and set II, respectively.

chiral  $SU(3)$  quark model for two different cases are shown, one is no tensor coupling of the vector mesons with  $f_{\text{chv}}/g_{\text{chv}} = 0$  (set I), another involves tensor coupling of the vector mesons with  $f_{\text{chv}}/g_{\text{chv}} = 2/3$  (set II). From the Table I, we can see that, compared to chiral  $SU(3)$  quark model, the coupling constants  $g_u^2$  and  $g_s^2$  of the OGE for both set I and set II cases, were greatly reduced when the vector meson field coupling is considered, which manifests that the OGE interaction is quite weak in the extended chiral  $SU(3)$  quark model. Instead of the OGE, the vector meson exchanges play dominate role in the short range part of the interaction between two quarks, so that the mechanism of the quark-quark short range interaction of the two models is totally different. The quark-quark short range interaction is from the OGE in the chiral  $SU(3)$  quark model, while it is mainly from vector meson exchanges in the extended chiral  $SU(3)$  quark model.

As mentioned above, the  $N\Omega$  and  $\Delta\Omega$  are very special two-baryon states since these two color singlet clusters have no common flavor quarks. Here we study the  $N\Omega$  and  $\Delta\Omega$  states by treating  $N(\Delta)$  and  $\Omega$  as two clusters and solving the corresponding RGM equation. Fig.1 shows the diagonal matrix elements of the Hamiltonian for the  $N\Omega$  system ( $\langle H_{N\Omega} \rangle$ ) in the generator coordinate method (GCM) [18] calculation, which includes the kinetic energy of the relative motion and the

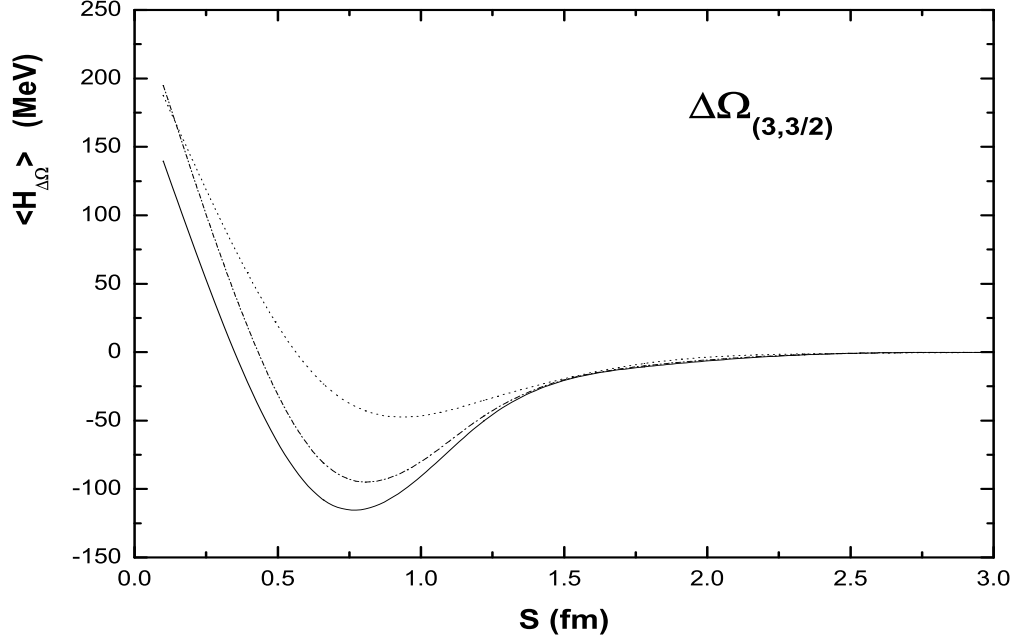


FIG. 2: The GCM matrix elements of the Hamiltonian for  $\Delta\Omega_{(3,3/2)}$  system. The dotted line represents the results obtained in original chiral  $SU(3)$  quark model, and the solid and dash-dotted lines represent the results in extended chiral  $SU(3)$  quark model with set I and set II, respectively.

effective potential between  $N$  and  $\Omega$  and can be regarded as the effective Hamiltonian of two clusters  $N$  and  $\Omega$  qualitatively.  $s$  denotes the generator coordinate which can qualitatively describe the distance between the two clusters. Similarly, Fig.2 shows the GCM diagonal matrix elements of the Hamiltonian for the  $\Delta\Omega$  system ( $\langle H_{\Delta\Omega} \rangle$ ). From Fig.1 and Fig.2, one can see that, there exists the medium range attractive interaction for  $N\Omega$  and  $\Delta\Omega$  systems. From our analysis, the attraction dominantly comes from the  $\sigma$  field coupling which is spin and flavor independent. To study whether such an attraction can make for a bound state of the  $N\Omega$  and  $\Delta\Omega$  systems, we solve the RGM equation for the bound state problem. The calculated binding energies and corresponding root-mean-square radii (RMS) of  $N\Omega$  and  $\Delta\Omega$  systems are tabulated in Table II. It is shown that in the original chiral  $SU(3)$  quark model, we get weakly bound states of  $N\Omega$  with 3.0 MeV binding energy and  $\Delta\Omega$  with 0.6 MeV, and the corresponding RMS are 1.2 fm and 1.3 fm, respectively.

The results of the extended chiral  $SU(3)$  quark model for two different cases are shown. In set I, i.e., there is no tensor coupling, the prediction of binding energy is 20.4 MeV for  $N\Omega$  state and 25.6 MeV for  $\Delta\Omega$  state. In set II, i.e., tensor coupling is involved, the prediction of binding energy is 12.1 MeV for  $N\Omega$  state and 14.4 MeV for  $\Delta\Omega$  state. Actually, as can be seen in Fig.1 and Fig.2,



TABLE III: Contributions of various terms to binding energy for  $N\Omega_{(2,1/2)}$  dibaryon, the unit for energy is in MeV.

	Chiral $SU(3)$ quark model	Extended Chiral $SU(3)$ quark model	
		set I	set II
$Kine$	23.1	44.7	34.4
$OGE$	0	0	0
$\pi$	0	0	0
$K$	6.0	13.4	9.8
$\eta$	0.9	2.2	1.5
$\eta'$	-0.6	-1.6	-1.1
$\sigma$	-55.0	-121.4	-93.2
$\sigma'$	0	0	0
$\kappa$	6.4	12.9	9.5
$\epsilon$	15.8	31.3	24.2
$\rho$		0	0
$K^*$		-1.1	1.9
$\omega$		0	0
$\phi$		0	0

the  $N\Omega$  and  $\Delta\Omega$  interactions in set I are more attractive than those other two cases, thus we get a relatively larger binding energies for  $N\Omega$  and  $\Delta\Omega$  states. Anyway, no matter whether the OGE or the vector meson exchange controls the quark-quark short range interaction, the main properties of  $N\Omega$  and  $\Delta\Omega$  keep unaffected, i.e., the  $N\Omega$  and  $\Delta\Omega$  systems are all not deeply bound states.

In Table III and Table IV, contributions of various terms to binding energies for  $N\Omega$  and  $\Delta\Omega$  dibaryons are given. We can see, in the chiral  $SU(3)$  quark model, there is no contribution from OGE, while the  $\sigma$  exchange dominantly provides the attractive interaction for  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems. In the extended chiral  $SU(3)$  quark model, there is no contribution from  $\rho$ ,  $\omega$  and  $\phi$  exchanges and little contribution from  $K^*$  exchange, and the attraction in these two special system also dominantly comes from  $\sigma$  exchange. Simultaneously, more attraction from  $\sigma$  meson can be obtained in extended chiral  $SU(3)$  quark model, the same as  $N\phi$  state [15]. In our calculation, the model parameters are fitted by the NN scattering phase shifts, and the mass of  $\sigma$  is adjusted by fitting the binding energy of deuteron, thus the value of  $m_\sigma$  is somewhat different for these three

TABLE IV: Contributions of various terms to binding energy for  $\Delta\Omega_{(3,3/2)}$  dibaryon, the unit for energy is in MeV.

	Chiral $SU(3)$ quark model	Extended Chiral $SU(3)$ quark model	
		set I	set II
$Kine$	19.7	53.7	39.3
$OGE$	0	0	0
$\pi$	0	0	0
$K$	3.6	12.6	8.8
$\eta$	1.9	8.6	5.6
$\eta'$	-1.3	-6.6	-4.1
$\sigma$	-46.2	-141.8	-105.9
$\sigma'$	0	0	0
$\kappa$	7.8	24.0	16.9
$\epsilon$	13.1	37.4	27.9
$\rho$		0	0
$K^*$		-11.5	-3.0
$\omega$		0	0
$\phi$		0	0

cases. In set I of the extended chiral  $SU(3)$  quark model, the mass of the  $\sigma$  meson is smaller than other two cases, thus  $N\Omega$  and  $\Delta\Omega$  can get more attraction and more binding energies are obtained.

## 2. Fit the KN process

Recently, both the chiral  $SU(3)$  quark model and the extended chiral  $SU(3)$  quark model have been extended from the study of baryon-baryon scattering processes to the baryon-meson systems [22] by solving a resonating group method (RGM) equation. In order to study the kaon-nucleon (KN) scattering, the scalar meson mixing between the flavor singlet and octet mesons must be considered to explain the experimental phase shift. Thus, it is interesting to see what would  $N\Omega$  and  $\Delta\Omega$  systems become after considering the scalar meson mixing for these two special systems? In our calculation, scalar  $\sigma$ ,  $\epsilon$  mesons are mixed from  $\sigma_0$  and  $\sigma_8$  with

$$\begin{aligned}
\sigma &= \sigma_8 \sin \theta^S + \sigma_0 \cos \theta^S, \\
\epsilon &= \sigma_8 \cos \theta^S - \sigma_0 \sin \theta^S,
\end{aligned} \tag{8}$$

The mixing angle  $\theta^S$  has been an open issue because the structure of the  $\sigma$  meson is still unclear and controversial. Here we adopt two possible values as did in [17, 22]. One is the ideal mixing with  $\theta^S = 35.264^\circ$ . This is an extreme case in which the  $\sigma$  exchange may occur only between u(d) quarks, while  $\epsilon$  occurs between s quarks. Another mixing angle with  $\theta^S = -18^\circ$  adopted was provided by Dai and Wu based on their investigation of a dynamically spontaneous symmetry breaking mechanism [21]. when we adopt the model parameters which are taken from Ref.[17] by fitting KN scattering processes, the calculated results show that both  $N\Omega_{(2,1/2)}$  and  $\Delta\Omega_{(3,3/2)}$  systems become unbound states for both ideally mixing and  $\theta^S = -18^\circ$ . We make an analysis for the  $N\Omega$  state. In first case, the mixing of scalar meson is taken to be the ideally mixing, the attraction from the  $\sigma$  meson has reduced to zero. In second case,  $\theta^S = -18^\circ$ , the attraction of the  $\sigma$  meson can be reduced a lot, thus the  $N\Omega$  become unbound state. For  $\Delta\Omega$  state, it is the same as the  $N\Omega$  state, the attraction from the  $\sigma$  meson has reduced to zero with the ideally mixing and the attraction of the  $\sigma$  meson can be reduced a lot with  $\theta^S = -18^\circ$ . The results tell us that the mixing  $\theta^S$  has large effect on the structure of  $N\Omega$  and  $\Delta\Omega$  dibaryons. For weakly bound system, the structure will be changed from bound state to unbound state when the mixing  $\theta^S$  is considered.

Here we would like to point out that when the mixing angle of scalar meson is considered, the parameters are obtained by fitting KN scattering processes, not by fitting NN and YN scattering processes. At the moment, we could not get a set of unified parameter to fit all of the scattering data of KN, NN and YN systems. However, we would like to see the effect on the structure of  $N\Omega$  and  $\Delta\Omega$  from various set of parameters. The results tell us that different sets of parameters have some effect on the structure of  $N\Omega$  and  $\Delta\Omega$  dibaryons, and the binding energies would changed with different sets of parameters. For these two weakly bound systems, the structure property could be changed from bound state to unbound state.

#### IV. SUMMARY

In this work, we dynamically study the structure of  $N\Omega$  and  $\Delta\Omega$  dibaryons with strangeness  $s = -3$  in the chiral  $SU(3)$  quark model as well as in the extended chiral  $SU(3)$  quark model by solving the RGM equation. All the model parameters are taken from our previous work. Firstly, we adopt the model parameters which can give a satisfactory description of the energies of the baryon ground states, the binding energy of the deuteron, and the NN scattering phase shifts. The calculated results show that, for  $N\Omega$  and  $\Delta\Omega$  systems, the effect from the vector meson fields is somewhat similar to that from OGE interaction. The  $N\Omega$  and  $\Delta\Omega$  dibaryons are still weakly bound

state when the vector meson exchanges control the short range part of the quark-quark interaction. Secondly, we take the model parameters with the mixing of scalar mesons by fitting KN scattering phase shifts. The result shows that the  $N\Omega$  and  $\Delta\Omega$  systems would become unbound both in the chiral  $SU(3)$  quark model and in the extended chiral  $SU(3)$  quark model. It should be noted that our current analysis of  $N\Omega$  and  $\Delta\Omega$  systems are based on the results from the fit to KN scattering processes, in which the scalar meson mixing must be considered.

There are some works on  $s=-3$  dibaryons. The  $N\Omega$  and  $\Delta\Omega$  states was also predicted by [23], and they think these two states are deeply bound states. Here in this work, we've got the different results with the Ref.[23]. Experimentally, whether there exist the  $N\Omega$  and  $\Delta\Omega$  bound states can help us to deeply understand the quark-quark interaction.

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